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Fourth Interim Report on contract R and D 5909-MO-01 "The Effect of
Twins on Critical Currents of High Tc Superconductors" - A.M. Campbell
and M.F. Ashby

The initial work on levitation forces and separation of
superconducting powders has divided into two projects which are being
pursued simultaneously.

The first is the nature of the frictional forces and damping on
levitated magnets. Although it is reasonable to suppose this arises
from AC losses in the superconductor, magnets rotating about their
centre of symmetry should not give fluctuating fields and should form
almost frictionless bearings.

A small coil was tracked across the rotating magnet and a map of
the field fluctuations obtained. The main ones were due to small
scratches in the magnet but there seemed to be a general noise level
of a few millitesla in a Sm Co 5 magnet with a mean field of about 0.5
T. Measurements of the friction at low speeds and the AC loss of the
superconductor were consistent with a model in which losses due to the
field fluctuations bring the magnet to rest. The friction is low
compared with good mechanical bearings, but the bearing is soft and
will not carry high loads. At higher speeds larger losses are caused
by a difference between the magnetic centre and the mechanical centre.

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This causes the magnet to wobble leading to large field fluctuations and losses.

The second project is the direct use of magnetic forces to separate particles of superconducting from non superconducting material. The major problem here has been the tendency of fine particles to stick together due to electrostatic forces. To overcome this we have formed a slurry of the material in liquid nitrogen and flash evaporated the nitrogen to blow the particles apart. This is reasonably successful but we do not yet know to what extent they will reagglomerate. A second problem is ensuring thermal equilibrium of the particles. This can be done fairly easily in a liquid slurry, but this limits the temperature range we can use and the liquid convection tends to counteract the separation process. We have now designed a magnetic track which particles will slide down with the non superconducting ones falling through as they travel. This will be tested shortly.

The final group of experiments is an investigation of the effect of material boundaries on critical current densities within grains. By doping with cobalt we change the twin spacing by a factor of over twenty, while doping with Zn has little effect. The effect on critical current densities is similar for the two dopants so we conclude that twins have no influence on J_c , acting neither as weak links, nor as pinning centres. A paper to be given at the Stamford conference on this topic is enclosed.



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THE EFFECT OF TWINS ON CRITICAL CURRENTS OF HIGH T_c SUPERCONDUCTORS

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Abstract

The effect of twin spacing on the J_c of YBaCuO is studied by doping with Co. and with Zn. The current density follows the variation of carrier density and inductive signal in both systems. The twins seem to have no effect although in the Co. doped samples their spacing varies by a factor of more than 30.

Introduction

A central problem in high T_c superconductors is the nature of the weak links and source of pinning in single crystals. Twins have been suggested in both roles but it is difficult to isolate the effect of twins from changes in basic superconducting parameters. Although both Zn. and Co. doping affect most parameters their effect on twin spacing is quite different so a comparison of the effect on J_c allows us to separate out the effect of the twins. All samples were prepared in a similar way by powder sintering. Except where stated all measurements were made on powders.

Structure

As Co. is added the twin spacing reduces dramatically. Beyond 2.8% occupation of Cu sites the structure is tetragonal with a smooth modulation. Fig.1 shows the twin spacing as a function of Co. doping. Zn. has no effect. on the twin structure.

Critical Temperature

The critical temperatures were measured both inductively and from the specific heat. The results are shown in Fig.2. Up to the tetragonal transition Co. doping has little effect on T_c while Zn. reduces it at small concentrations.

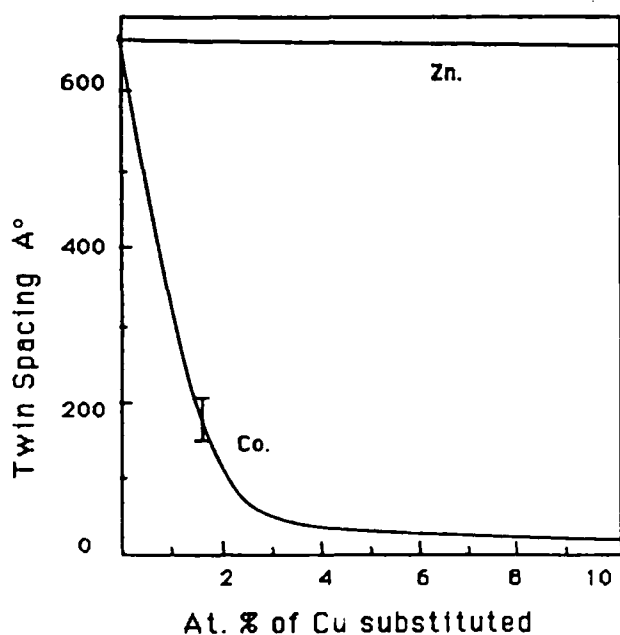


Fig.1

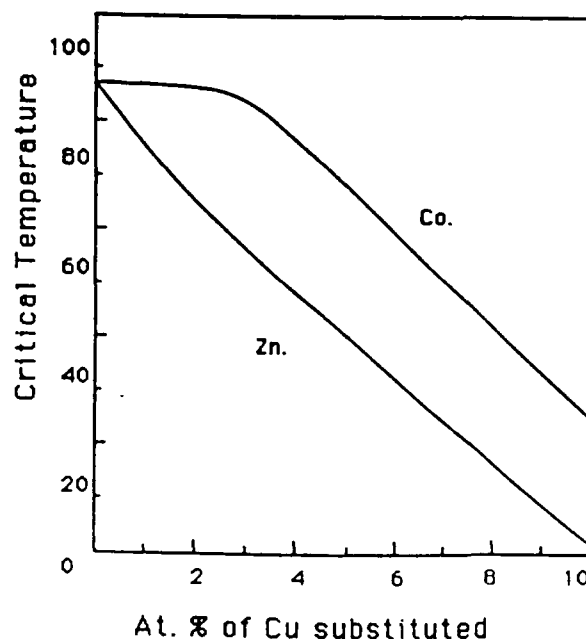


Fig.2.

Inductive Signal

The size of the inductive signal is plotted in Fig.3. This is reduced from the start of Co. doping although T_c is not changing. This is associated with a reduction in the number of carriers as measured by the specific heat. Since there is no sign of second phases and the signal from sintered samples is not reduced we interpret this as indicating that the penetration depth has become comparable with the particle size, which is about 20 microns.

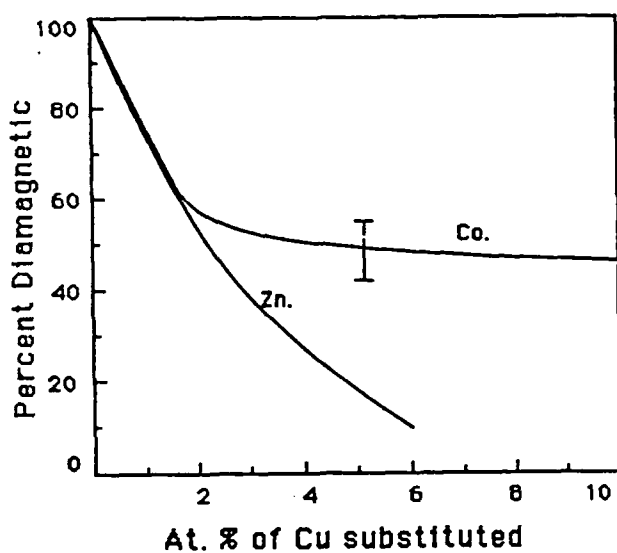


Fig.3.

Critical Current Density.

Critical current densities were measured from magnetisation curves at 4.2K and from A.C. susceptibility at 77K. The He temperature results are shown in Fig.4. There was a good deal of scatter between samples which may be due to differences in microstructure or in particle size. Since the reduction in diamagnetic response is taken to be a penetration depth effect all samples were normalised by the calibration factor of the undoped samples. To obtain the absolute values for J_c a current loop size of one micron was assumed. Measurement on Co. doped samples at nitrogen temperatures showed a similar variation, with J_c down by a factor of about 20.

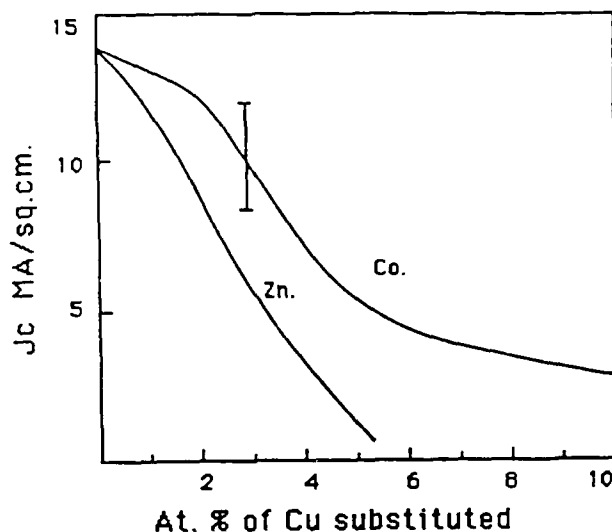


Fig.4

Discussion

Up to the tetragonal transition the variation of J_c is similar for both Co. and Zn. doping. Although the doping affects the basic superconducting parameters somewhat differently the results are consistent with pinning dependent mainly on the carrier density. There is no correlation with the huge variation in twin structure caused by the Co. doping alone. We therefore conclude that the twins are not the dominant pinning mechanism, nor do they act as weak links either in Helium or Nitrogen. This conclusion would not be altered by other interpretations of the reduction in inductive signal. Although qualitatively consistent with the specific heat measurements and also with a reduction observed in low field magnetisation these effects are not large enough to explain a penetration depth of the order of many microns at 4.2K.

Acknowledgements

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